OPTIMIZATION OF A SHORT FARADAY CUP FOR LOW-ENERGY IONS USING NUMERICAL SIMULATIONS

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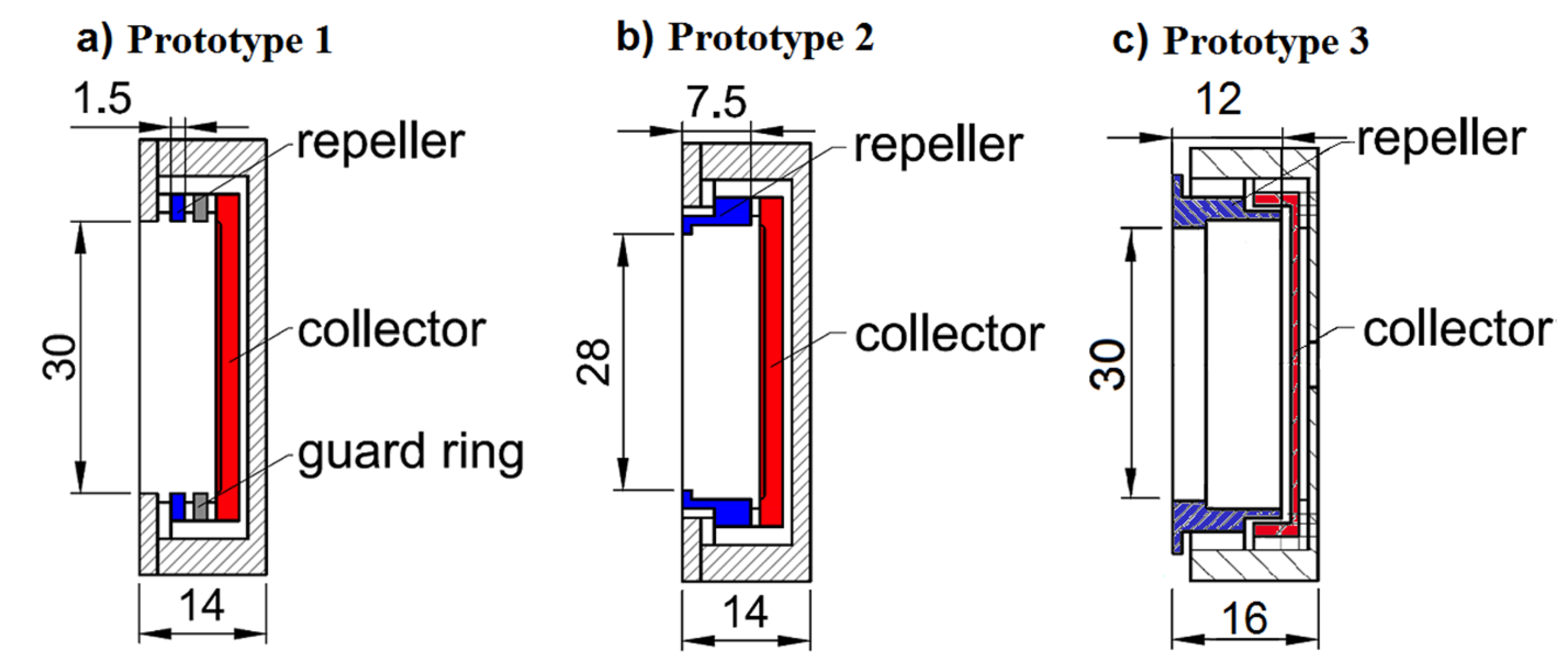
INTRODUCTION

ISOLDE, the heavy-ion facility at CERN is undergoing a major upgrade with the installation of a superconducting LINAC that will allow post-acceleration of ion beams up to 10 MeV/u. In this framework, customized beam diagnostics are being developed in order to fulfill the design requirements as well as to fit in the compact diagnostics boxes foreseen. The main detector of this system is a compact Faraday cup that will measure beam intensities in the range of 1 pA to 1 nA. In this contribution, simulation results of electrostatic fields and particle tracking are detailed for different Faraday cup prototypes taking into account the energy spectrum and angle of emission of the ion-induced secondary electrons.

COMPACT FARADAY CUP

The Faraday cup used at the previous REX-ISOLDE LINAC has been redesigned into a much more compact version in order to fit in the short (58 mm in length) diagnostic boxes of HIE-ISOLDE. The Faraday cup to be used in HIE-ISOLDE must have a 30 mm diameter aperture in order to cover the maximum beam sizes in HIE-ISOLDE ($1\sigma_{rms}=5$ mm). Prototype 3 is the final design, optimizing the length of the repeller ring (12 mm) relative to the maximum length available for the cup (16 mm). In addition, the cup's length was optimized with a thinner collector electrode, insulators and body of the Faraday cup.

This Faraday cup will be used to measure pilot ion-beams with a mass-to-charge ratio A/q≤4.5 in order to set up the HIE-ISOLDE superconducting LINAC in the intensity range of 1-1000 pA.



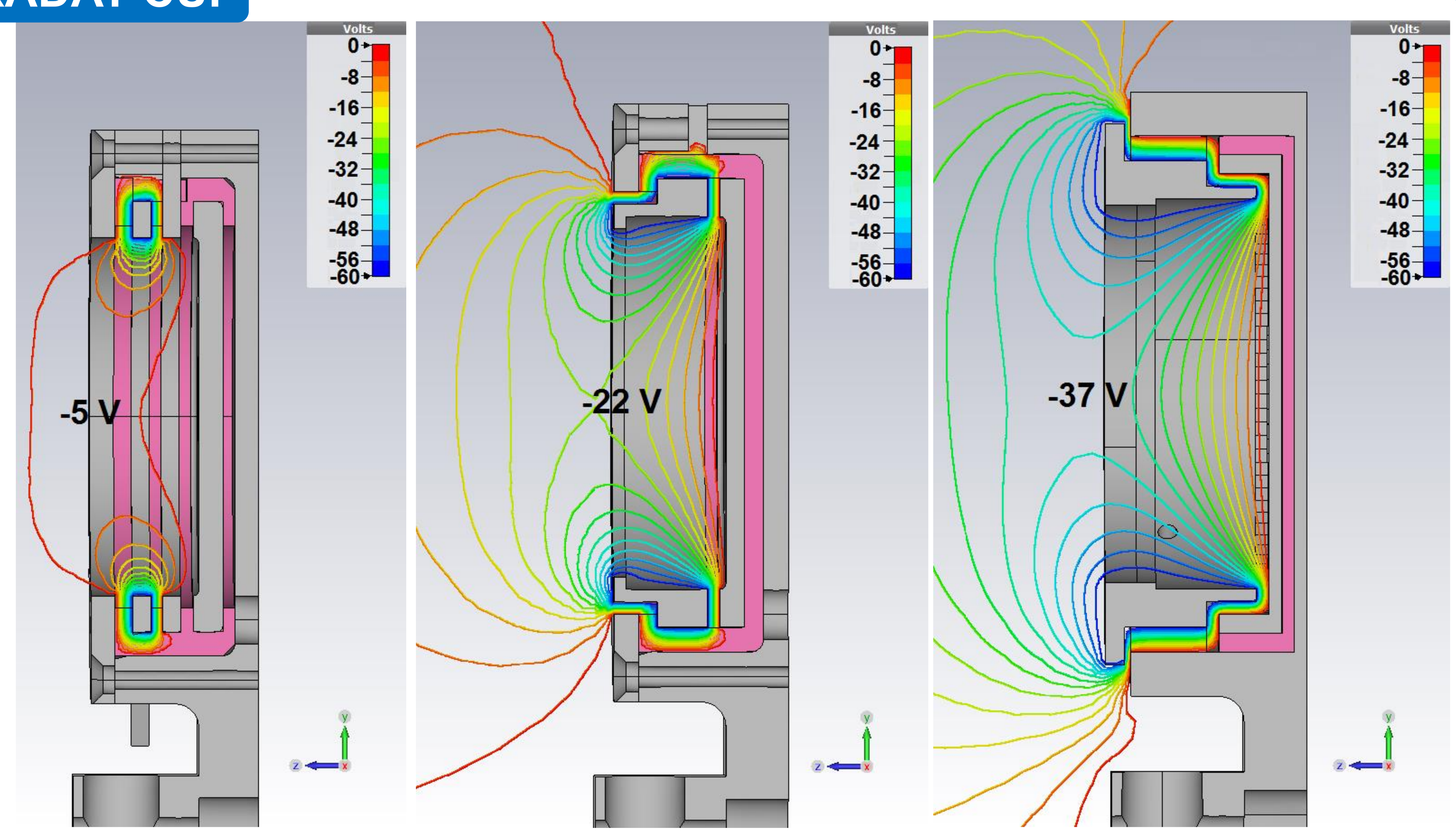
Cross section of the different Faraday cup prototypes developed.

ELECTROSTATIC SIMULATIONS: POTENTIAL IN THE FARADAY CUP

Numerical simulations have been done in order to assess the design of the Faraday cups, analyzing the electrostatic potential distribution and the secondary electron emission. CST Particle Studio was used to study the electrostatic fields and particle tracking in these cups. The electrostatic potential in the central axis of the Faraday cup varies according to the length and radius of the cup. The electrostatic potential is a maximum in the repeller ring and has a minimum in the centre, corresponding to the beam axis.

Extending the repeller ring in the direction of the beam axis results in an increased potential barrier in the centre of Prototype 3, capturing secondary emission in the cup more efficiently.

CST



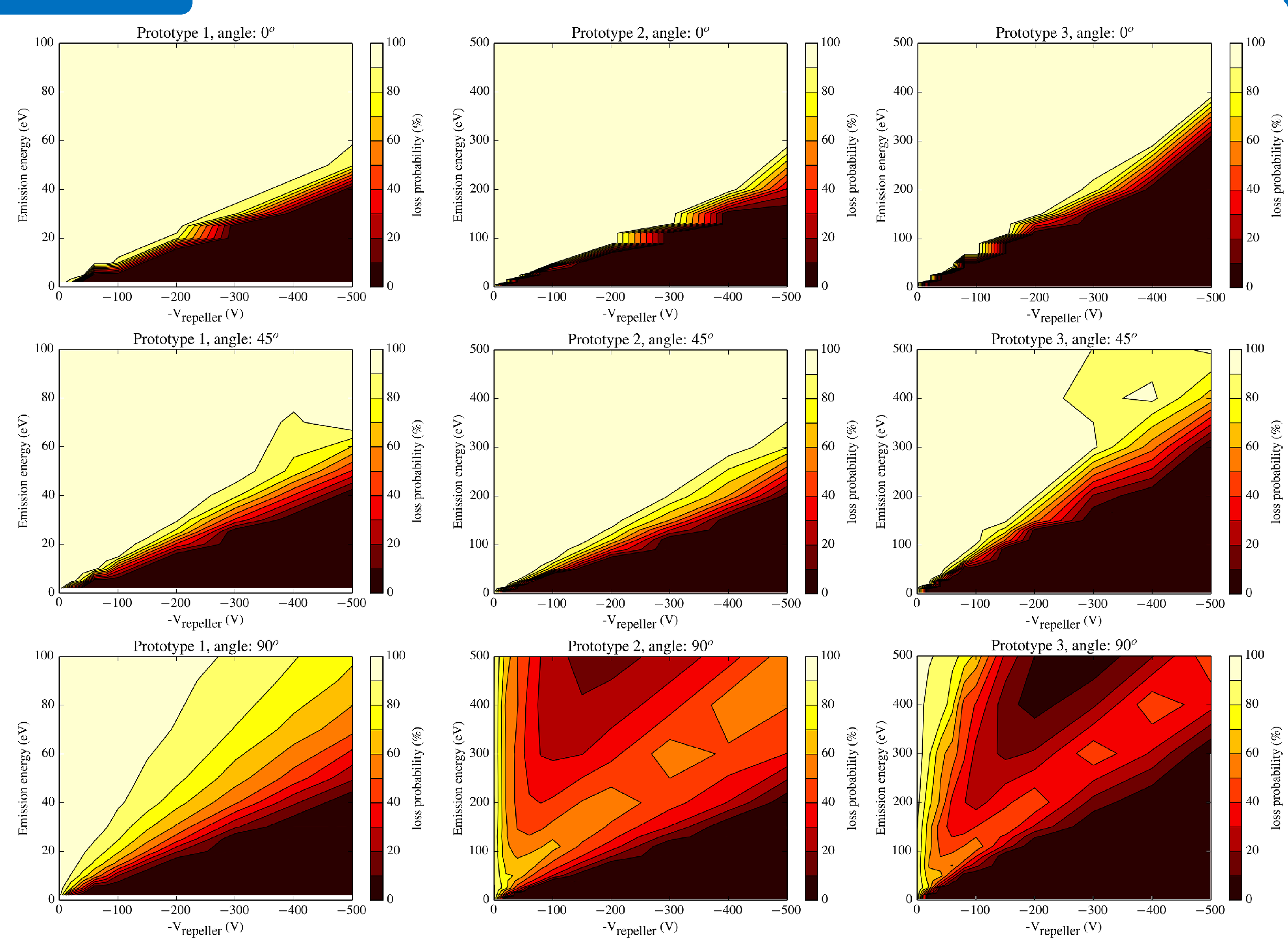
Electrostatic Potential in the different prototypes biased at -60 V.

PARTICLE TRACKING SIMULATIONS: LOSS PROBABILITY

Particle tracking simulations were run to study the charge loss probability of the different Faraday cup prototypes when emitting electrons at different emission energies and angle cones from the point of impact of an ion beam centered on the cup.

- Electron emission energies: 0 to 500 eV
- Repeller voltage: 0 to -500 V
- Emission angles: 0°, 45° and 90°

The probability of charge losses in Prototype 3 is significantly reduced with low bias voltages, thanks to a favorable geometric design.



Loss probability of ion-induced electrons in the different Faraday cup prototypes.

CONCLUSIONS & OUTLOOK

A compact Faraday cup has been designed, optimized and built as part of the R&D program of beam diagnostics for the HIE-ISOLDE superconducting LINAC. In Prototype 3, the increase in the potential barrier is more than a factor 8, resulting in a better efficiency capturing secondary electrons.

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This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 264330.